CLAIMS

WHAT IS CLAIMED IS:

1. A touch sensing device, comprising:

a touch panel;

a plurality of sensors coupled to the touch panel, the plurality of sensors configured to sense bending waves in the touch panel and generate a bending wave signal responsive to the sensed bending waves;

a transducer coupled to the touch panel and configured to induce bending waves in the touch panel; and

a controller coupled to the plurality of sensors, the controller configured to identify an untouched condition signal responsive to the induced bending waves, compare the untouched condition signal to the bending wave signal, and detect a touch on the touch panel based on the comparison.

2. The device of claim 1, wherein:

the touch panel is substantially rectangular; and

the plurality of sensors comprises at least three sensors positioned at corners of the touch panel.

3. The device of claim 1, wherein the plurality of sensors comprise piezoelectric sensors.

4. The device of claim 1, wherein the transducer comprises a piezoelectric transducer.

5. The device of claim 1, wherein the transducer is configured to induce bending waves in the touch panel at a single frequency.

6. The device of claim 1, wherein the transducer is configured to induce bending waves in the touch panel at multiple frequencies.

7. The device of claim 1, wherein the transducer is configured to induce bending waves in the touch panel at a frequency greater than or equal to half the sampling frequency used by the controller.

8. The device of claim 1, wherein the transducer is configured to induce bending waves in the touch panel at a frequency associated with an aliased untouched condition signal.

9. The device of claim 8, wherein the aliased untouched condition signal comprises a signal having a frequency less than or equal to an audio band frequency.

10. The device of claim 8, wherein the aliased untouched condition signal comprises a DC signal.

11. The device of claim 1, wherein the controller is configured to determine a difference between the bending wave signal and the untouched condition signal and detect the touch based on the difference.

12. The device of claim 1, wherein the controller is configured to determine an amplitude of the untouched condition signal, compare the untouched condition signal amplitude to an amplitude of the bending wave signal, and detect the touch based on the comparison.

13. The device of claim 12, wherein the amplitude is an RMS amplitude.

14. The device of claim 1, wherein the controller is configured to determine a spectrum of the untouched condition signal, compare the untouched condition signal to a spectrum of the bending wave signal, and detect the touch based on the comparison.

15. The device of claim 1, wherein the controller comprises an adaptive filter having a

plurality of reference filter coefficients selected to cancel the untouched condition signal and the controller is configured to calculate the filter coefficients to cancel the bending wave signal, compare the calculated filter coefficients to the reference filter coefficients and detect a touch based on the comparison.

16. The device of claim 1, wherein the controller is further configured to determine the location of the touch after detecting the touch.

17. The device of claim 1, wherein the controller is further configured to detect a touch lift off from the touch panel after detecting the touch.

18. The device of claim 1, wherein the controller is configured to compare the bending wave signal to the untouched condition signal after detecting the touch and detect the touch lift off based on the comparison.

19. The device of claim 1, wherein the controller is configured to detect a touch lift off from the touch panel if the bending wave signal returns to the untouched condition signal.

20. A touch system, comprising:

a touch screen, comprising:

a touch panel;

a plurality of sensors coupled to the touch panel, the plurality of sensors configured to sense bending waves in the touch panel and generate a bending wave signal responsive to the sensed bending waves;

a transducer coupled to the touch panel and configured to induce bending waves in the touch panel; and

a controller coupled to the plurality of sensors, the controller configured to identify an untouched condition signal responsive to the induced bending waves and detect the touch on the touch panel based on a difference between the bending wave signal and the untouched condition signal;

a display viewable through the touch screen and configured to display information;

and

a processor coupled to the display and configured to process the information to be displayed on the display.

21. The touch system of claim 1, wherein the display comprises a light emitting diode display.

22. The touch system of claim 1, wherein the display comprises a liquid crystal display.

23. The touch system of claim 1, wherein the display comprises a cathode ray tube display.

24. The touch system of claim 1, wherein the controller is further configured to detect a touch lift off from the touch panel after detecting the touch.

25. The touch system of claim 1, wherein the controller is further configured to compare the bending wave signal to the untouched condition signal after detecting the touch, and detect a touch lift off from the touch panel based on the comparison.

26. The touch system of claim 1, wherein the controller is further configured to compare the bending wave signal to the untouched condition signal after detecting the touch, and detect a touch lift off based on a return of the bending wave signal to the untouched condition signal.

27. A method for determining touch information, comprising:

inducing bending waves in a touch panel using a driving signal;

identifying an untouched condition signal responsive to the induced bending waves;

generating a bending wave signal responsive to a touch on the touch panel;

comparing the bending wave signal and the untouched condition signal; and

detecting the touch on the touch panel based on the comparison.

28. The method of claim 27, wherein inducing the bending waves in the touch panel using the driving signal comprises inducing the bending waves using a single frequency driving signal.

29. The method of claim 27, wherein inducing the bending waves in the touch panel using the driving signal comprises inducing the bending waves using a multiple frequency driving signal.

30. The method of claim 27, wherein inducing the bending waves in the touch panel using the driving signal comprises inducing the bending waves in the touch panel using a broadband frequency driving signal.

31. The method or claim 27, wherein inducing the bending waves in the touch panel using the driving signal comprises inducing the bending waves in the touch panel using a driving signal associated with an aliased untouched condition signal.

32. The method of claim 27, further comprising updating the identified untouched condition signal based on non-touch related conditions.

33. The method of claim 32, wherein updating the identified untouched condition signal comprises updating the identified untouched condition signal due to component drift.

34. The method of claim 32, wherein updating the identified untouched condition signal comprises periodically updating the identified untouched condition on a timescale selected to be long compared to a touch duration.

35. The method of claim 27, wherein:

comparing the bending wave signal to the untouched condition signal comprises

determining a difference between the bending wave signal and the untouched condition signal; and

detecting the touch based on the comparison comprises detecting the touch if the difference is beyond a threshold value.

36. The method of claim 27, wherein:

identifying the untouched condition signal comprises determining an amplitude of the untouched condition signal; and

comparing the bending wave signal and the untouched condition signal comprises comparing the amplitude of the untouched condition signal to an amplitude of the bending wave signal.

37. The method of claim 27, wherein:

identifying the untouched condition signal comprises determining a spectrum of the untouched condition signal; and

comparing the bending wave signal and the untouched condition signal comprises comparing the spectrum of the untouched condition signal to a spectrum of the bending wave signal.

38. The method of claim 27, wherein:

identifying the untouched condition signal comprises selecting a plurality of reference filter coefficients of an adaptive filter to cancel the untouched condition signal;

comparing the bending wave signal and the untouched condition signal comprises calculating filter coefficients to cancel the bending wave signal and comparing the calculated filter coefficients to the reference filter coefficients; and

detecting the touch based on the comparison comprises detecting the touch based on a difference between the calculated filter coefficients and the reference filter coefficients.

39. A method for determining touch information, comprising:

inducing bending waves in a touch panel using a driving signal;

identifying an untouched condition signal responsive to the induced bending waves;

generating a bending wave signal responsive to a touch on the touch panel;

detecting a touch on the touch panel;

comparing the bending wave signal and the untouched condition signal after the touch is detected; and

detecting a touch lift off from the touch panel based on the comparison.

40. The method of claim 39, wherein detecting the touch lift off comprises detecting the touch lift off based on a return of the bending wave signal to the untouched condition signal.

41. The method of claim 39, wherein inducing the bending waves in the touch panel using the driving signal comprises inducing the bending waves at single fundamental frequency.

42. The method of claim 39, wherein inducing the bending waves in the touch panel using the driving signal comprises inducing the bending waves at multiple frequencies.

43. The method of claim 39, wherein inducing the bending waves in the touch panel using the driving signal comprises inducing the bending waves using a broadband frequency driving signal.

44. The method or claim 39, wherein inducing the bending waves in the touch panel using a driving signal comprises inducing the bending waves in the touch panel using a driving signal associated with an aliased untouched condition signal.

45. The method of claim 39, wherein:

identifying the untouched condition signal comprises determining an amplitude of the untouched condition signal; and

comparing the bending wave signal and the untouched condition signal comprises

comparing an amplitude of the bending wave signal to the amplitude of the untouched condition signal.

46. The method of claim 39, wherein:

identifying the untouched condition signal comprises determining a spectrum of the untouched condition signal; and

comparing the bending wave signal and the untouched condition signal comprises comparing the spectrum of the untouched condition signal to a spectrum of the bending wave signal.

47. The method of claim 39, wherein:

identifying the untouched condition signal comprises selecting a plurality of reference filter coefficients of an adaptive filter to cancel the untouched condition signal; and

comparing the bending wave signal and the untouched condition signal comprises:

calculating filter coefficients to cancel the bending wave signal; and

comparing the calculated filter coefficients to the reference coefficients.

48. The method of claim 39, wherein detecting the touch on the touch panel comprises:

comparing the bending wave signal and the untouched condition signal; and

detecting the touch on the touch panel based on the comparison.

49. The method of claim 39, further comprising:

generating a wake on touch signal responsive to the touch; and

energizing the emitting transducer if the wake on touch signal is generated.

50. A touch sensing method, comprising:

detecting a touch on a touch panel by one or more of a plurality of touch detection processes, at least one of the plurality of touch detection processes based on a bending wave induced in the touch panel by a driving signal; and

initiating a touch location process after detecting the touch.

51. The method of claim 50, wherein the at least one touch detection process comprises:

inducing the bending wave in the touch panel using the driving signal;

identifying an untouched condition signal responsive to the induced bending waves;

generating a bending wave signal responsive to a touch on the touch panel;

comparing the bending wave signal and the untouched condition signal; and

detecting the touch on the touch panel based on the comparison.

52. The method of claim 50, further comprising detecting a touch lift off after detecting the touch.

53. A system for determining touch information, comprising:

means for inducing bending waves in a touch panel using a driving signal;

means for identifying an untouched condition signal responsive to the induced bending waves;

means for generating a bending wave signal responsive to a touch on the touch panel;

means for comparing the bending wave signal and the untouched condition signal; and

means for detecting the touch on the touch panel based on the comparison.

54. The system of claim 53, further comprising means for updating the identified untouched condition signal based on non-touch related conditions.

55. A system for determining touch lift off information, comprising:

means for inducing bending waves in a touch panel using a driving signal;

means for identifying an untouched condition signal responsive to the induced bending waves;

means for generating a bending wave signal responsive to a touch on the touch panel;

means for detecting the touch on the touch panel;

means for comparing the bending wave signal and the untouched condition signal; and

means for detecting a touch lift off from the touch panel based on the comparison.

56. The system of claim 55, further comprising:

means for generating a wake on touch signal responsive to the touch; and

means for energizing the emitting transducer if the wake on touch signal is generated.